EFFECTS OF AMELIORATION PROCEDURES ON LUMBRICIDS IN ACIDIC FOREST SOILS UNDER PINUS SYLVESTRIS

F.Makeschin
Lehrstuhl für Bodenkunde, Universität München, München, BRD

ВЛИЯНИЕ МЕЛИОРАТИВНЫХ МЕРОПРИЯТИЙ НА ДОЖДЕВЫХ ЧЕРВЕЙ В КИСЛЫХ ЛЕСНЫХ ПОЧВАХ ПОД СОСНЯКАМИ PINUS SILVESTRIS

Ф.Макешин
Кафедра почвоведения Мюнхенского университета, Мюнхен, ФРГ

Pine sites degraded by man's activities (e.g. litter gathering, burning, extensive harvesting) take a large part of the forests of Northeastern Bavaria (South Germany). The amounts and the turnover of nutrients,especially nitrogen, are low, resulting in limited tree growth. These sites are characterized by biological inactive raw humus layers, low pH and base saturation, and a typical acidophytic ground vegetation, formed by dwarf shrubs, mosses and lichens. Earthworms occur in this soils only very sparsely as acid-tolerant forms (Dendrobaena sp., L.rubellus); their influence upon litter fragmentation and incorporation is negligible.

T a b l e 1. Site characteristics of the study area

Parameters	Waldsassen (WAL)	Pfreimd (PFR)
Elevation	530 m	480 m
Precipitation	610 mm	650 mm
Temperature	5.8°C	7.2°C
Geology	phyllite	cretaceous sediments with diluv. loess depositions
Soil type	podzolic brown earth	podzolic pseudogley

20-30 years ago a series of amelioration trials were started on podzolic brown forest soils in order to improve the fertility of formerly degraded sites. The amelioration techniques envolve liming, N-, P-, K- and Mg- fertilization, tilling and underplanting with lupins in close older pine stands as well as biotechnical procedures (deep ploughing, liming, planting of black alder or other deciduous trees) after clearcutting or heavy thinning.

The aim of the present study was to investigate the long-term effects of different amelioration procedures upon size and structure of the earthworm fauna in acidic forest soils.

Site Description and Methods

The Site characteristics are given in Table 1.

The description of the amelioration procedures is shown in Table 2.

Lumbricids were sampled at three dates per year (May, August, October) during 1982-1984. The number of sampling in each experiment is given in Table 2. 20-30 randomized sampls were obtained per experimental unit and sampling date, depending on size and number of replications of the plots. Individual sample size was 1600 cm^2. After cutting off the ground vegetation the organic layer was removed into plastic bags and later handsorted in the laboratory. Earthworms from the mineral soil were extracted using a 0.35% Formalin solution. Abundance and species composition of the lumbricids were determined.

Results and Discussion

The typical acidophytic ground vegetation of the control plots was replaced to a certain extend by grasses, herbs, ferns and shrubs at the ameliorated sites, indicating improved upper soil conditions /9,8/. The needle and leaf litter at the ameliorated sites show an increased quality and palatability due to smaller C/N- ratios and higher contents of phosphorus and basic cations /1,3,8/. These long term effects certainly cause a better food supply for animal decomposers either directly or via stimulated microorganisms populations (/7/). The ameliorated sites show generally higher abundances of predators (chilopods: Lithobiomorpha, staphylinids) (Makeschin, unpublished).

T a b l e 2. Description of the amelioration procedures, soil characteristics and abundance and species composition of lumbricids in the amelioration experiments

Site	WAL	WAL	WAL	WAL	WAL	PFR	PFR	PFR
Experiment	control plots	complete fertilization	lupine underplanting	soil amelioration	forest fallowing	control plots	complete fertilization	lupine underplanting
Vegetation	pine	pine	pine	grey alder	pine, oak, maple birch, hornbeam	pine	pine	pine
Amelioration procedures		1964	1964	1955	1951		1964	1964
	-	40 dt lime	40 dt lime	clear cutting	thinning	-	40 dt lime	40 dt lime
	-	10 dt basic slag	10 dt basic slag			-	10 dt basic slag	10 dt basic slag
		4 dt sulfata of K and Mg	4 dt sulfata of K and Mg	100 dt lime	$>$100 dt lime		4 dt sulfata of K and Mg	4 dt sulfata of K and Mg
		3 dt superphos	3 dt superphos tillage	ploughing	ploughing	-		tillage "lupine"
							3x5 dt nitro-chalk	
		3x5 dt nitro-chalk	"lupine"	planting of grey alder	planting of broad-leaf trees			
Soil characteristics:								
humus form	raw humus	mor (raw humus like)	mor (typ.-mull like)	F-mull	F-mull/mor	raw humus	mor (typ.-mull like)	F-mull
pH($CaCl_2$) (0-10/10-20 cm)	3.1/3.6	3.3/3.7	3.4/3.7	3.5/3.6	3.9/4.0	3.6/4.0	4.4/4.2	4.4/4.3
Ca-saturation, % (CEC)(0-10/10-20 cm)	4/3	25/12	34/16	27/34	63/55	5/4	55/22	54/32
Earthworms:								
samplings	5	2	3	9	7	2	2	5
abundance (N/m^2)	< 0.1			16(2/39)	39(12/84)	6(2/10)	38 (21/55)	41(22/62)
Adults (%):		no	no	30	22	39	26	15
D.octaedra	sparse	influence	influence	66	32	100	42	38
D.illyrica	sparse	by	by	24	19	-	-	-
D.rubida	sparse			5	4	-	3	5
L.rubellus	sprase	amelioration	amelioration	5	6	-	55	56
A.rosea	-			-	12	-	-	-
O.lacteum	-			-	27	-	-	1

Abundance and species composition of lumbricids are given in Table 2.

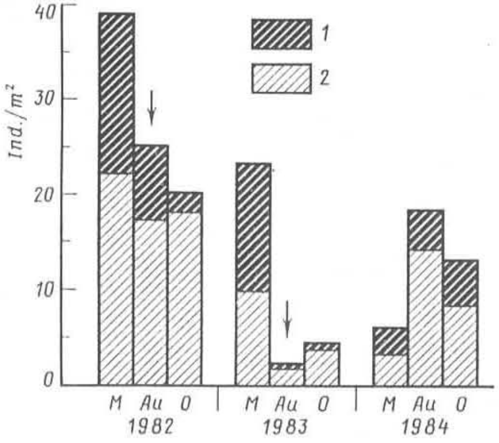
At the Waldsassen site (WAL) amelioration in close pine stands didn't show any marked effect on earthworms. A significant increase in earthworm populations occurred only after heavy liming, ploughing and planting of deciduous trees. There the population increased although no drastic reduction of soil acidity (indicated by the pH-values) was visible. However, the Ca-saturation (CEC) in the upper soil was high especially in the experiment "forest-fallowing". At this site A.rosea and O.lacteum are abundant beside D.octaedra, D.illyrica and D.rubida, which occur also in very low numbers in the control site. D.illyrica, common together with D.octaedra in forest soils of Middle Germany /2/, apparently reaches in the Waldsassen area its widest Western extension. L.rubellus in spite of heavy liming and increased quality of broadleave litter still shows low population densities.

At the Pfreimd site (PFR) already moderate fertilization (and base input) in close pine stands increased the earthworm populations, particulary that of L.rubellus (this species was found at the control sites only as juveniles). Their activities resulted in the formation of active humus forms especially in the lupine treatment (Table 2). The form of N-input (see Table 2) either as N-fertilizers or as biological input via lupins (together with tillage at the beginning of the experiment) didn't result in a different size and species composition of lumbricid populations. Both treatments were established in 1964 parallel to the Waldsassen site, where no effects upon lumbricids could be found. The soil characteristies at Pfreimd generally show lower soil acidity and higher Ca-saturation, however. Other lumbricid species than the autochthonous D.octaedra, D.rubida and L.rubellus were not found at the Pfreimd site, with the only exception of O.lacteum occurring at one sampling date in small numbers concentrated at one point of the lupine-treatment. Generally the earthworm biomass is low, not exceeding 10-12g fresh weight/m^2.

The ameliorated sites are located in the midst of pine forests all characterized by very acid raw humus layers. Therefore immigration from more distant agricultural area into ameliorated sites is nearly impossible. That is the reason why normally only autochthonous lumbricids could be advanced by amelioration, except there was a passive introduction together with soil adherent to seedlings or plough or an active inoculation respectively (both could be supposed in the case of "forest-fallowing" in WAL).

Summer drought caused a significant decrease in earthworm populations in WAL together with a strong reduction of adults (Fig.1). This effect seems to be less drastic in the Pfreimd-site with pseudogley soils characterized by a higher maintainance of soil moisture during the summer period. It is also supposed that a negative interaction exists between extreme climatic factors (drought, frost) and the poor base status of the Waldsassen soil.

Huhta et al. /5/ showed a decline in lumbricid densities in Scots pine forest soils after fertilization and a subsequent increase beginning 3 years after. However, due to the general paucity of the earthworms, the results must be observed carefully. In spruce forest soils Franz /4/ and Huhta /6/ report an increase in lumbricid populations after liming. In the experiment reported by Huhta (l.c.) it was especially L.rubellus that raised its popu-



Seasonal abundance of lumbricids in the experiment WAL "soil amelioration" during 1982–1984
1 – adults, 2 – juvenils; arrows indicate dry summers

lation densities 10-20 fold while D.octaedra only showed a slight increase. Further investigations are underway to find out, to what exten~~d~~t the different reactions of the L.rubellus populations after amelioration in the WAL and PFR site can be explained by the different base status of the soils.

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